

“DOOR TO DRAWER” COSTS OF CURATION, INSTALLATION, DOCUMENTATION, DATABASING, AND LONG-TERM CARE OF MAMMAL VOUCHER SPECIMENS IN NATURAL HISTORY COLLECTIONS

ROBERT J. BAKER, LISA C. BRADLEY, HEATH J. GARNER, AND ROBERT D. BRADLEY

ABSTRACT

Natural history specimens and their associated data are a valuable resource to the scientific and educational communities, with each specimen representing a unique sample from a specific locality and a specific point in time. Given this intrinsic value to research and education, a few studies have attempted to assign a monetary value or worth to specimens and their associated data. For example, a recent study determined the costs associated with collecting and preparing a mammal voucher specimen in the field; however, little information is available for costs associated with incorporating these specimens and their data into a natural history collection and providing access to these data by the scientific community and society. Herein, we review the costs required for curating, installing, documenting, databasing, and caring for a representative sample of 3,356 mammal voucher specimens, associated genetic resources, and accompanying data in the Natural Science Research Laboratory, Museum of Texas Tech University. The average cost for curation, installation, documentation, and databasing is conservatively estimated to be \$17.51 per specimen, with additional costs of \$0.25 per year per specimen for long-term care.

Key words: archival costs, genetic resources, natural history collections, searchable database, voucher specimens

INTRODUCTION

The importance and role of natural history collections to science and education have been discussed by many authors (Lane 1996; Suarez and Tsutsui 2004; Wandeler et al. 2007; Mares 2009; Anderson 2012). The comparison between natural history collections and libraries (Winker 2004) is apropos; both provide an opportunity for educational advancement through examination of the material contained within their respective walls (specimens or books). Libraries and natural history collections expend substantial efforts in obtaining new acquisitions; although this is a necessary step for initiating and expanding each resource, it is only the beginning phase. Eventually, both entities must develop a system to effectively and efficiently archive these resources for an extended period of time (perhaps hundreds of years) and ultimately provide the appropriate clientele/users access to the items contained within their collections. In addition, once the resource is established, substantial efforts and resources are required to maintain the facility on a daily basis and

to provide various types of services to its users. Thus, acquiring, caring for, and providing access to archived collections requires substantial monetary investment, in perpetuity. For natural history collections, few studies have been conducted that attempt to put a dollar value on specimens (Bradley et al. 2012). However, with sources of funding for research, academia, and natural science collections becoming increasingly limited and competitive, it is critical to understand the financial investment involved in collecting, archiving, and providing access to these important resources.

Concerning the acquisition side of institutional efforts, Bradley et al. (2012) reviewed the costs associated with collecting, preparing, and transporting mammal voucher specimens and associated tissues to the door of the Natural Science Research Laboratory (NSRL), a division of the Museum of Texas Tech University (MoTTU). Sixty-one field trips, conducted between 2000 and 2011, and the specimens collected

during those trips were chosen as representative of collecting efforts of the NSRL (local, regional, and international trips, various preparation types, various trip durations, etc.). Using that subset of data as a model, it was determined that the average cost per voucher was \$41 for specimens collected locally or regionally and \$74 for specimens collected on international trips (Bradley et al. 2012).

Although the study by Bradley et al. (2012) provided an estimate of the cost of obtaining specimens at a field site and transporting them to the NSRL, it did not consider the cost of the additional activities associated with readying specimens and their associated data for installation into the collection (and ultimately providing access to the specimens and data to the scientific community and to society), nor did it estimate the cost of long-term care for the collection. In fact, only a few studies provide cursory information concerning these

costs (Anderson 1973; Anderson and Choate 1974; Lee et al. 1982; Blackmore et al. 1997; Genoways et al. 2003) and essentially no study provides a detailed, comprehensive view that allows for an accurate estimate of the total expenses required for archiving and properly caring for natural history collections. The study by Blackmore et al. (1997) provides a cursory estimate for the acquisition, curation, and accommodation (maintenance) for a variety of collections housed in The Natural History Museum of London; although their values are useful in a broad sense, they lacked the specific details necessary for calculating cost on a per specimen basis. Herein, we extend our initial efforts in Bradley et al. (2012) by estimating the costs from “door to drawer” associated with curating, installing, and documenting mammal voucher specimens and their associated tissues, providing an online, searchable database, and the annual cost of caring for such collections.

METHODS

Costs were separated into three primary categories: curation and installation; documentation and databasing; and long-term care. For the purposes of this manuscript, we define “curation” as the initial procedures required to prepare specimens for permanent installation in the collection (e.g., placing skeletal material in the bug colony for cleaning, osteoscribing bones, placing cleaned skulls and skeletons in vials and boxes, etc). Each category is explained in more detail below. For each category, costs for consumable supplies and labor were estimated on a per specimen basis. Non-consumable supplies (e.g., computers and printers, laboratory instruments such as forceps, tongs, etc.) were not factored into supply costs. Supply costs were based on current (2013) prices when ordered in quantities typical for the NSRL. Minutes-per-specimen estimates for each procedure were determined based on the results of time-trials conducted by NSRL personnel experienced in the pertinent tasks. Labor costs were based on the average FY 2013-2014 salary rates of the NSRL personnel that typically conduct each task (Table 1). Procedures and supplies that were considered in our estimates are provided in Appendices I and II, respectively. All NSRL procedures used in the generation of the database for this manuscript follow the Collection Management Policy and Procedures of

the Museum of TTU (www.depts.ttu.edu/museumttu/facilities&policies.html) and are the basis of accreditation by the American Society of Mammalogists and the American Alliance of Museums.

Time-trials to estimate minutes-per-specimen for each procedure represented “best-case scenarios” and did not account for interruptions and problems that are typically encountered during actual curatorial procedures (e.g., replacing ink cartridges, deciphering hand writing, etc.). Therefore, we consider these estimations to be reflective of the minimum time required to complete each task. Similarly, we did not attempt to account for situations that potentially could result in wasted supplies during curatorial activities (e.g., fluid spills, misprinted labels and tags), and consequently, we consider our estimates for supply expenses to be a minimum cost per specimen. Also, it is important to recognize that time and expenses associated with curating, installing, documenting, and caring for a mammal collection may vary, relative to that reported herein, depending on the experience and efficiency of staff, type of specimens, unique or specific collection operating procedures, opportunities to purchase supplies in bulk quantities, etc.

Table 1. Personnel salaries used in calculating labor costs for the curation, installation, documentation, databasing, and long-term care of mammal voucher specimens, tissue samples, and associated data.

| Personnel | Average Salary |
|--------------------------------------|------------------|
| Faculty Curators | \$58.04 per hour |
| Curator of Collections | \$20.96 per hour |
| Genetic Resources Collection Manager | \$17.60 per hour |
| Graduate Students | \$7.75 per hour |
| Undergraduate Students | \$7.50 per hour |

The first expense category that we considered was the cost associated with curating and installing specimens. The procedures, supplies, and time involved in this process vary depending on the type of specimen preparation (traditional dried skin, skeletal materials, fluid-preserved) or specimen component (tissues), as well as the size of the specimen. For our analysis, specimens were subjectively classified to size as follows: extra-small (e.g., *Reithrodontomys*, *Perognathus*, shrews); small (e.g., *Peromyscus*, bats); medium (e.g., *Sigmodon*, *Neotoma*); or large (e.g., *Sylvilagus*, *Sciurus*, *Mephitis*). There obviously are larger mammal categories not included in our calculations, such as large carnivores, ungulates, elephants, whales, etc., but no large specimens were collected during the six field trips used in our analyses, nor are they common specimens in most natural history collections. However, we acknowledge that large mammal vouchers would have greater associated costs for supplies and curatorial procedures.

The typical procedures for curating and installing traditional specimens upon their arrival at the NSRL can be summarized as follows: 1) assignment of material to appropriate staff members and inventory of incoming items (specimens, tissues, field notes and data books, etc.); 2) skin and skeletal specimens subjected to pest management protocols (frozen at -20°C for 2 weeks); 3) skeletal material enters the dermestid colony, followed by hand cleaning and osteoscribing; 4) skeletal material is stored in appropriate box or vial; 5) skeletal material is matched with skin; 6) specimen is catalogued (after data are proofed and species iden-

tification is confirmed); and 7) specimen is installed into the appropriate drawer and case of the collection. For fluid specimens, the field preservative (formalin or ethanol) is decanted, specimens are inventoried, rinsed in ethanol (multiple times as needed), re-labeled with alcohol resistant ink and tags (if needed), housed in appropriate jars, catalogued, and installed into cabinets. For tissues, the vials are inventoried, sorted, re-labeled as necessary, cell-boxed, and installed into -80°C freezers or on shelves (non-frozen samples in EtOH or lysis buffer) in the Genetic Resources Collection.

The second expense category estimated pertains to costs associated with documentation and handling of data. Documentation procedures include: scanning and organizing field notes and storing in archival boxes, proofing TK books (TK books contain the primary data page for each specimen) for complete data and entering data into spreadsheets, proofing spreadsheets and importing into online, searchable databases, updating TK books with assigned catalogue numbers and species identifications, scanning TK books, and completing accession documentation with the Registrar.

The third expense category we considered was the cost of long-term care for proper maintenance of the specimens. These costs result primarily from the time involved (personnel salaries) to conduct routine surveys and duties required under normal collection activities. Few supplies, other than ethanol to replace fluids in the Fluid Collection, are required during maintenance activities. Maintenance procedures considered in our estimates include: complete inventories every 10 years

for the dry and fluid collections (~10% of each collection per year), periodic spot checks (~1.5% of each collection per year), checking fluid levels in the Fluid Collection and replacing ethanol as needed (~5% of Fluid Collection per year), checks of the dry collection for pests (quarterly), monitoring freezers (daily), checking organization of dry and fluid collections (~10% of collection per year), and database updates (~ 8 hours/week). These are recurring expenses that, although they may be periodic in occurrence, continue in perpetuity as part of normal collection responsibilities of curation. Therefore, we extrapolated each expense to a yearly basis to determine the annual maintenance cost per specimen by preparation type. We did not include time or cost estimates for general collection maintenance procedures that are independent of the number or type of specimens being archived. For example, we did not include the time involved in general cleaning and organization of the collection areas or the monitoring of insect pest activity in the building through the use of sticky traps, etc.

Bradley et al. (2012), in order to determine an overall average cost to prepare a specimen in the field, selected six field trips that were considered representative of recent NSRL collecting efforts with regards to the ratio of specimen sizes and preparation types. The number of mammal vouchers, by preparation type and size, and the number of tissue samples obtained from the six field expeditions are presented in Table 2. In this study, we utilized the samples from these same six field trips in order to calculate an overall average “door to drawer” cost per specimen. After estimating the labor and supply costs for curating and installing, documenting and databasing, and caring for a single mammal voucher specimen of each preparation type and size, as explained above, we multiplied these values by the number of specimens of each type and size that were obtained from the six field trips. Total costs were then divided by the total number of specimens (3,356) to determine an overall average cost per specimen.

Table 2. Number of mammal voucher specimens, by preparation type and size, and number of tissue vials obtained during six NSRL field expeditions. These trips are considered representative of NSRL collecting efforts in terms of the ratios of specimen preparation types and sizes.

| Preparation | Honduras 2001 | Honduras 2004 | Kyrgyz Republic 2007 | Mexico 2008 | Texas, Oklahoma 2010 | Texas, Oklahoma, Kansas 2011 |
|----------------------------------|------------------|------------------|----------------------------|----------------|----------------------------|---------------------------------------|
| Traditional (skin plus skeleton) | | | | | | |
| extra-small | 10 | 3 | 13 | 43 | 21 | 36 |
| small | 433 | 425 | 0 | 276 | 227 | 289 |
| medium | 1 | 2 | 1 | 11 | 55 | 74 |
| large | 2 | 0 | 0 | 0 | 1 | 4 |
| Skeletal material only | | | | | | |
| extra-small | 0 | 0 | 1 | 52 | 14 | 8 |
| small | 1 | 183 | 1 | 50 | 18 | 172 |
| medium | 0 | 0 | 6 | 4 | 0 | 6 |
| large | 2 | 2 | 0 | 0 | 4 | 0 |

Table 2. (cont.)

| Preparation | Honduras 2001 | Honduras 2004 | Kyrgyz Republic 2007 | Mexico 2008 | Texas, Oklahoma 2010 | Texas, Oklahoma, Kansas 2011 |
|---------------------------------|------------------|------------------|----------------------------|----------------|----------------------------|---------------------------------------|
| Fluid-preserved | | | | | | |
| Initially fixed in 10% formalin | 664 | 0 | 157 | 67 | 0 | 0 |
| Initially fixed in 70% ethanol | 0 | 0 | 0 | 0 | 11 | 0 |
| Tissue vials | | | | | | |
| Frozen or ethanol-preserved | 5,528 | 3,710 | 492 | 2,989 | 2,063 | 3,532 |
| Lysis-preserved | 0 | 0 | 449 | 0 | 0 | 0 |
| Total specimens | 1,113 | 615 | 185 ¹ | 503 | 351 | 589 |

¹ Six specimens were represented by tissues only.

RESULTS

Results of our analysis of the estimated time, labor costs, and supply costs for the curation and installation (by preparation type and specimen size), documentation and databasing, and annual maintenance of a single mammal voucher specimen and tissues (by vial) are presented in Table 3. As expected, time and labor costs for curation and installation were higher for larger voucher specimens. The cost of curating and installing fluid preparations was slightly higher for specimens initially fixed in formalin than those initially fixed in ethanol, due to the extra rinsing required as the specimens are transferred into 70% ethanol. Overall, curation and installation of fluid preparations were less expensive than for most categories of dried preparations. Curation and installation costs for tissues averaged approximately \$1 per vial. Documentation and databasing costs were a relatively minor component of the overall cost of a voucher. Documentation and databasing primarily involves time (labor costs) but few consumable supplies, due to the fact that most documentation activities are electronic (scanning, entering data into databases, etc.). Similarly, long-term care

costs were almost exclusively dependent on personnel time and involve few supplies.

When the estimated costs per preparation type and size (Table 3) were applied to the 3,356 specimens collected during the six field expeditions (Table 2), the total estimated cost to curate, install, and document these specimens was \$58,749.70, for an overall average cost of \$17.51 per specimen (Table 4). Of the \$17.51 per specimen, \$12.11 was for personnel salaries and \$5.40 was for supplies and materials. The estimated annual maintenance cost for these specimens was \$823.26, for an overall average cost of \$0.25 per specimen per year, of which \$0.23 was for personnel salaries and \$0.02 was for supplies and materials. When analyzing the numbers in terms of time, rather than cost, we estimated that an average of 48 minutes of personnel time was required to curate, install, and document each specimen, and at least 1 minute per specimen was required for maintenance activities each year.

Table 3. Estimated time (minutes), labor costs, and supply costs for the curation and installation, documentation and databasing, and annual care of a single mammal voucher specimen (by specimen preparation type and size) and associated tissues (per vial). See Appendices I and II for summaries of NSRL procedures and supplies, respectively, considered in these estimates. All costs are rounded to the nearest \$0.01.

| Item | Estimated minutes per specimen | Estimated labor cost per specimen | Estimated supply cost per specimen | Estimated total cost per specimen |
|---|--------------------------------|-----------------------------------|------------------------------------|-----------------------------------|
| Curation and Installation | | | | |
| Traditional specimen (skin plus skeleton) | | | | |
| extra small | 34 | \$9.25 | \$1.96 | \$11.21 |
| small | 34 | \$9.33 | \$3.67 | \$13.00 |
| medium | 36 | \$9.50 | \$4.03 | \$13.53 |
| large | 39 | \$9.88 | \$11.61 | \$21.49 |
| Skeletal material only | | | | |
| extra small | 27 | \$3.98 | \$1.95 | \$5.93 |
| small | 27 | \$3.98 | \$3.66 | \$7.64 |
| medium | 29 | \$4.24 | \$4.01 | \$8.25 |
| large | 32 | \$4.62 | \$11.59 | \$16.21 |
| Fluid preparation | | | | |
| Initial fixation in 10% formalin | 11 | \$5.96 | \$0.55 | \$6.51 |
| Initial fixation in 70% ethanol | 11 | \$5.89 | \$0.47 | \$6.36 |
| Tissues (per vial) | | | | |
| Frozen or ethanol-preserved | 3 | \$0.62 | \$0.47 | \$1.09 |
| Lysis-preserved | 3 | \$0.61 | \$0.35 | \$0.96 |
| Documentation and Databasing | 4 | \$1.06 | \$0.01 | \$1.07 |
| Long-term Care ¹ | | | | |
| Traditional and skeletal preparations | 0.46 | \$0.07 | \$0.00 | \$0.07 |
| Fluid preparations | 0.37 | \$0.09 | \$0.01 | \$0.10 |
| Tissues (per vial) | 0.10 | \$0.03 | \$0.00 | \$0.03 |

¹ Long-term care costs are adjusted for frequency of occurrence of each procedure, to reflect an average annual effort.

Table 4. Estimated costs associated with the curation and installation (C and I), documentation and databasing (D and D), and long-term care (LTC) of 3,356 mammal voucher specimens and associated tissues resulting from six NSRL field expeditions. Curation and installation costs take into account the number of specimens of each size and preparation type resulting from each trip (Table 2). Curation, installation, documentation, and databasing costs are one-time expenses for each specimen. Long-term care costs are based on an average one-year cost, and continue in perpetuity.

| Date | Locality | Curation and Installation (C and I) | | | | Documentation and Databasing (D and D) | Total Expenses for C, I, D and D | Total Specimens | Average Cost per Specimen for C, I, D and D | Average Annual Cost per Specimen for LTC |
|-------------------|-------------------------|-------------------------------------|----------------------------|--------------------|--------------|--|----------------------------------|-----------------|---|--|
| | | Traditional Preparations | Skeleton-only Preparations | Fluid Preparations | Tissue Vials | | | | | |
| 3-24 Jul 2001 | Honduras | \$5,797.61 | \$40.06 | \$4,322.64 | \$6,025.52 | \$1,190.91 | \$17,376.74 | 1,113 | \$15.61 | \$0.24 |
| 10-25 Jul 2004 | Honduras | \$5,585.69 | \$1,430.54 | \$0.00 | \$4,043.90 | \$658.05 | \$11,718.18 | 615 | \$19.05 | \$0.25 |
| 16 Jun-3 Jul 2007 | Kyrgyz Republic | \$159.26 | \$63.07 | \$1,022.07 | \$967.32 | \$197.95 | \$2,409.67 | 185 | \$13.03 | \$0.25 |
| 12-29 Jul 2008 | Mexico | \$4,218.86 | \$723.36 | \$436.17 | \$3,258.01 | \$538.21 | \$9,174.61 | 503 | \$18.24 | \$0.25 |
| 27 Jul-9 Aug 2010 | Texas, Oklahoma | \$3,952.05 | \$285.38 | \$69.96 | \$2,248.67 | \$375.57 | \$6,931.63 | 351 | \$19.75 | \$0.24 |
| 22 Jul-6 Aug 2011 | Texas, Oklahoma, Kansas | \$5,247.74 | \$1,411.02 | \$0.00 | \$3,849.88 | \$630.23 | \$11,138.87 | 589 | \$18.91 | \$0.25 |
| Total | | \$24,961.21 | \$3,953.43 | \$5,850.85 | \$20,393.30 | \$3,590.92 | \$58,749.70 | 3,356 | \$17.51 | \$0.25 |

DISCUSSION

The costs determined for initial curation, installation, documentation and databasing, and long-term care of voucher specimens reported herein were based on our personal and professional experiences with mammal specimens deposited in the NSRL. All costs were based on standard NSRL procedures, typical NSRL supply costs, and NSRL staff salary rates. These costs are expected to vary for other natural history museums, depending on factors such as the procedures and supplies utilized by a museum, specific curatorial needs of the collections, database requirements, and personnel availability, experience, and salary rates. As a reminder, the estimates presented herein represent a conservative approach, and in some instances are not all-encompassing relative to the total expenses experienced during curation, installation, and documentation and databasing activities. Further, our estimated costs are not expected to be applicable for collections of other taxonomic groups (birds, reptiles, amphibians, fish, invertebrates, etc.) or non-traditional types of collections (e.g., taxidermy, pelts); however they should provide a gross estimate for similar activities. Although the values reported herein apply specifically to the NSRL's mammal collection, they nevertheless are enlightening and provide a point of discussion and comparison. We encourage other natural history museums to conduct similar studies of the costs associated with collecting specimens (e.g., Bradley et al. 2012) and the costs of curating, installing, documenting, and caring for specimens of other taxonomic groups and specimen preparation types, for comparison and valuation purposes.

Although there are some limitations to the data presented in this manuscript, the data provide researchers and natural history museum administrators with documented examples of the costs for archiving mammal specimens in a museum accredited by the American Society of Mammalogists and the American Alliance of Museums. This type of data, in part, can be useful for justifying the current financial value of a collection, anticipating costs associated with collection growth, and estimating future curatorial expenses. For example, using the average cost of collecting, field-prepping, and transporting a specimen to the NSRL (\$56; Bradley et al. 2012) and the average cost

of curating, installing, documenting, and databasing a specimen as reported in this manuscript (\$17.51), it would cost a minimum of \$8,563,915 (\$6,524,000 for collecting and \$2,039,915 for curation activities) in today's dollars to replace the Mammal Collection of the NSRL (116,500 catalogued specimens and the associated tissues and data), with additional collection care and maintenance costs of at least \$29,125 annually. In addition, the time required to curate, install, and document and database the 116,500 mammal specimens currently housed in the NSRL is minimally estimated to be 93,200 personnel-hours. Further, the maintenance procedures considered in our analysis are estimated to require at least 1,942 personnel-hours per year for the entire mammal collection.

The total monetary cost of expanding, maintaining, and operating a natural history collection, however, goes far beyond the costs associated with specimen acquisition and care that are reported in Bradley et al. (2012) and in this paper. For example, there are costs associated with providing services to the scientific community (e.g., processing and shipping loans, answering information requests, providing identification services, providing on-site access to specimens by visiting researchers, other activities required to be accredited by professional organizations such as the American Society of Mammalogists and the American Alliance of Museums), conducting outreach activities (e.g., giving tours, developing museum exhibits), handling daily operations (e.g., ordering supplies, training students), and administering such a facility, as well as substantial costs for physically establishing and maintaining the facilities that house the collections (e.g., building construction, furnishings and equipment such as replacement freezers, specimen cabinets, computer upgrades, etc., electricity and other utilities, custodial services, pest control, security services, building maintenance and repairs, etc.). These costs are largely dependent on the size and type of facility, available staffing, and the use of the facility by the science, education, and public communities. Therefore these expenses cannot reasonably be viewed on a cost-per-specimen basis, but they represent real costs of operating a natural history museum and contributing to advancements in scientific research, education, and public outreach.

The substantial costs of collecting and properly archiving specimens as estimated in Bradley et al. (2012) and in this study illustrate, in part, the need for financial support for natural history collections by university and museum administrators, scientific communities, and funding agencies such as the National Science Foundation, National Institutes of Health, and the Institute of Museum and Library Services. It is clear that it is expensive to collect, prepare, and properly archive natural history collections and to ensure that these irreplaceable specimens and data are available to researchers for future use. As new methods continue to be developed for extracting genetic and toxicological data from specimens (Baker 1994; Rocque and Winker 2005; Wandeler et al. 2007; Rowe et al. 2011;) and as new uses for traditional specimen data become more pertinent (e.g., ecological niche modeling, GIS, climate modeling, and distributional studies - Anderson 2012; Feeley and Silman 2011; Suarez and Tsutsui 2004), the potential for resolving scientific questions that can be addressed by well-curated and accessible collections and associated data will increase (Baker et al. 1998; Parker et al. 1998). Toward this end, we agree with Groppe and Mares (2009) and many others that it is imperative to encourage funding agencies and administrators to identify the mechanisms to adequately fund the activities required of natural history collections so that they can continue to support the scientific community. Further, we support the contention of Blackmore et al. (1997) that it is appropriate for the systematics community to present sound calculations concerning the value of scientific collections so that others less knowledgeable of these resources can appreciate their true worth.

The goal of this study was simply to estimate the monetary costs necessary to: 1) archive mammal

voucher specimens and their associated tissues, 2) database specimen information and make that information available and searchable via online data portals, and 3) provide proper maintenance and care for specimens and their data. From the onset, it was realized that the results of this study could be interpreted as a negative cash flow, and the natural history collection potentially could be construed as a liability to the university. However, if the cost of archiving and caring for the collection is viewed as a “monetary investment” by the university (and other funding agencies), then rubrics can be defined to measure the “success” of such an investment. Although we object to the idea that simple accounting methods be used to determine the true value of a scientific resource, the initial comparison to a library resurfaces. Libraries require a substantial investment (buildings, new acquisitions, salaries, maintenance, utilities, etc.) by the institution and at the end of the day this investment is gauged by the quality of the education received by the students and the scholarship of the faculty. Likewise, for natural history collections, one could quantify: 1) the number and quality of publications produced by the users (faculty and students), 2) the number of graduate students utilizing the collections for their research degrees, 3) placement of graduate students in professional or influential positions, 4) grants received for research associated with specimens and data housed in the collection, 5) number of loans to the scientific community, etc., and determine if the recognition returned to the university exceeded the investment (see Editorial, page *i*). Many of these factors are beyond the scope of this study and will be addressed in Bradley et al. (in prep.), in which we discuss the importance and value of natural history collections to science, education, and society.

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Addresses of authors:

ROBERT J. BAKER

*Department of Biological Sciences and Natural
Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
robert.baker@ttu.edu*

HEATH J. GARNER

*Natural Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
heath.garner@ttu.edu*

LISA C. BRADLEY

*Natural Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
lisa.bradley@ttu.edu*

ROBERT D. BRADLEY

*Department of Biological Sciences and Natural
Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
robert.bradley@ttu.edu*

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APPENDIX I

Typical procedures utilized by the NSRL for curation and installation (by preparation type), documentation and databasing, and long-term care of mammal voucher specimens and tissues. Curation and installation procedures are presented in general chronological order, from the time the specimens are brought to the NSRL facility until the specimens are installed in their permanent locations in the NSRL collections.

Curation and InstallationTraditional (dried skin and skeleton) preparations:

Dried skins:

- Unpin skins from pinning board
- Bag, box, and freeze skins for 2 weeks (pest control measure)
- Remove from freezer and allow to acclimate for 24 hours
- Remove skins from bag, box, and sort by TK number
- Arrange skins in specimen trays
- Conduct an inventory of skins and enter into a computer file
- Arrange inventoried skins in temporary holding cabinets

Skeletal material:

- Freeze skeletal material for 2 weeks (pest control measure)
- Place skeletal material into vent hoods for drying
- Pre-sort large skeletal collections (numerically) into sub-lots
- Inventory skeletal material (into computer file) and arrange into numbered lots
- Arrange skeletal material in numbered ziplock bags by lot number
- Freeze for 2 weeks (additional pest control measure)
- Remove from freezer and allow to acclimate for 24 hours
- Place in holding cabinet until the dermestid colony is available
- Place skeletal material in dermestid colony by lot number
- Periodically check condition of specimens/maintain colonies
- Remove skeletal material from dermestid colony and place in storage bins
- Freeze for 2 weeks
- Let acclimate for 24 hours
- Hand clean and re-house skeletal material into appropriate sized vial or box
- Organize skeletal material by TK number

Skins and skeletons:

- Match skins with skeletal material
- Update inventory file
- Identify specimens to species (confirm or correct field identifications)
- Update inventory file and store matched specimens in temporary holding cabinet
- Generate database printout for osteoscribing
- Osteoscribe skeletal material and write catalogue number on skeleton tag
- Print data labels for skeletal material
- Insert labels with skeletal material
- Write data and catalogue number on skin tags as necessary

APPENDIX I (CONT.)

Write final species ID on skin tag in pencil
Sort specimens for installation and arrange in final specimen tray
Place skeletal material in vial trays and install specimens in permanent collection location

Fluid Preparations:

Unpack specimens, unwrap, and rinse in water
Inventory specimens
For specimens originally preserved in formalin, place in jars with 35% ethanol for 1 week, then 50% ethanol for 1 week
Place all specimens in jars with 70% ethanol
Identify specimens
Prepare alcohol tags (print, trim, drill, cut, string)
Tie catalogue number tags on specimens
Change out ethanol and sort into install jars
Double-check inventory per jar and print and affix jar labels
Place jars in collection

Tissues:

Remove frozen vials from liquid nitrogen dewar
Place all vials into temporary boxes
Record tissues into processing log
Conduct initial inventory (into computer file) of temporary boxes
Sort tissues for cell boxing
Print and adhere replacement barcodes as necessary
Place sorted tissues in cryo boxes
Add/correct numbering on tissue caps as necessary and verify inventory
Print tissue box summary labels
Install in final location
Update location in processing log and incorporate inventory into database

Documentation and Databasing

Scan collector field-notes and enter into database
Create summary list and organize field notes
Email a PDF copy of field notes to collector
Place original field notes in archival storage box
Complete accession paperwork with catalog numbers for Registrar
Registrar completes accessions paperwork for specimens
Check TK book (data, missing data, inventory, etc.) and enter TK book data into Microsoft Excel spreadsheet
Proof spreadsheet and import finalized data into Vertebrate Database
Update database with accession information from Registrar
Update TK book with catalogue numbers
Update species identifications in TK book
Scan TK book
Export data to online, searchable database portals

APPENDIX I (CONT.)**Long-term Care**

Check fluid collection levels and replace as necessary
Perform spot-checks of collection inventories
Monitor temperatures of freezers in the Genetic Resources Collection
Check for pests in dry specimen cabinets
Check organization of collections and reorganize as necessary
Update online, searchable database as necessary
Perform complete dry and fluid collection inventories every 10 years

APPENDIX II.

Consumable supplies utilized by the NSRL for curation, installation, documentation, databasing, and long-term care of mammal voucher specimens and tissues. Costs of these supplies were considered in estimating supply costs per specimen (by preparation type and size).

Curation and InstallationTraditional (skin and skeleton) preparations:

replacement straight pins
disposable nitrile gloves
150 liter trash bags
1.9 liter and 0.9 liter zippered plastic bags
rubber bands
rapidograph pens, replacement tips, and ink for osteoscribing
regular ink pens
permanent markers for labeling plastic bags
toner for printer
cotton swabs, for removing rapidograph ink
95% ethanol, for removing rapidograph ink
100% cotton rag paper for labels
archival foil-backed label stock for box labels
plastic vials to protect specimen tag while in dermestid colony
soufflé cups for separating specimens in dermestid colony
glass shell vials (2 & 7 dram) for skulls and skeletons
archival boxes for skull/skeleton boxes (various sizes)
archival paper trays for organizing specimens and skeletal material
foam to line shelves and specimen drawers
% drawer space (purchase drawers as necessary)
% case space (purchase cases as necessary)

APPENDIX II (CONT.)

Fluid-preserved specimens:

jars (3.8 liter, 1.9 liter, 0.9 liter)
95% ethanol (diluted to 70%)
spun bound polyester medium for tags and labels
thermal transfer printer ribbon for tags and labels
linen string
% cabinet space (purchase cabinets as necessary)

Tissues (frozen, ethanol-preserved, lysis-preserved):

cardstock for cryo box summaries
toner for printer
tape
permanent markers
cryo boxes and cell dividers
replacement cryo labels
% freezer rack (purchase racks as necessary)
% freezer space (purchase freezers as necessary)
lysis tissue sample boxes and dividers
parafilm
% lysis rack (purchase racks as necessary)
% lysis shelving unit (purchase shelving as necessary)

Documentation and Databasing

archival boxes for storing field notes

Long-term Care

95% ethanol, diluted to 70%, for refilling jars